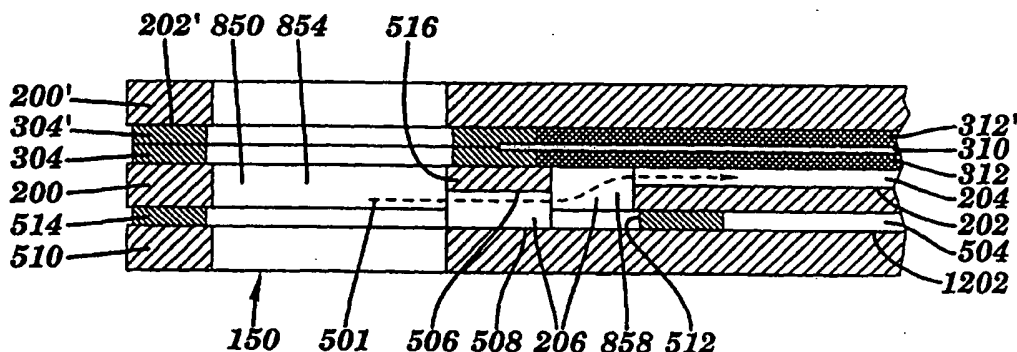




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : H01M 8/24, 8/02	A1	(11) International Publication Number: WO 00/21153 (43) International Publication Date: 13 April 2000 (13.04.00)
(21) International Application Number: PCT/US99/23283 (22) International Filing Date: 6 October 1999 (06.10.99) (30) Priority Data: 09/167,359 7 October 1998 (07.10.98) US (71) Applicant (for all designated States except US): PLUG POWER, INC. [US/US]; 968 Albany-Shaker Road, Albany, NY 12110 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): MARVIN, Russel, H. [US/US]; 45 Upper Wedgewood Lane, Voorheesville, NY 12186 (US). CARLSTROM, Charles, H., Jr. [US/US]; 6 Wilden Way, Clifton Park, NY 12065 (US). (74) Agent: ROTHENBERG, Jeff; Heslin & Rothenberg, P.C., 5 Columbia Circle, Albany, NY 12203 (US).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: FUEL CELL ASSEMBLY UNIT FOR PROMOTING FLUID SERVICE AND DESIGN FLEXIBILITY**(57) Abstract**

A first flow field plate (200) of a fuel cell assembly (100) includes a first flow channel (204) thereon. Fluid is conducted to the flow channel through an opening (858) extending through the first plate. An adjacent second plate (510) cooperates in providing a surface (508) for a flow path (501) between a manifold (854) and the opening (858). Additional surface(s) (506, 512) may cooperate in providing the flow path (501) and/or structural support therefor. A formation (862) on the first plate (200) impedes fluid communication from the manifold (854) on a plate face (202) including the first flow channel (204). The formation may provide structural support in a (e.g., PEM-type) fuel cell assembly (100), and/or a clamping and/or gasketing function for a membrane electrode assembly (310). A second flow path may similarly be provided for humidification of the (e.g., reactant) fluid. The second flow path may include flow regulator(s) and/or metering orifice(s) (860). The second plate (510) may include a second flow channel thereon (1204). Flow path(s) for the second plate may be configured to provide the aforementioned surface (508) or the flow path for the first plate without interference among fluid service for each plate. A multiplication of manifolds for a fluid may allow a manifold to omit service for a plate, where a different manifold provides the omitted service.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

FUEL CELL ASSEMBLY UNIT FOR PROMOTING FLUID SERVICE AND DESIGN FLEXIBILITY

TECHNICAL FIELD

This invention relates, generally, to fuel cell assemblies and, more
5 particularly, to fluid service as well as fluid flow plate configuration and
positioning for fuel cell assemblies.

BACKGROUND ART

Fuel cells electrochemically convert fuels and oxidants to electricity, and
fuel cells can be categorized according to the type of electrolyte (e.g., solid
10 oxide, molten carbonate, alkaline, phosphoric acid, or solid polymer) used to
accommodate ion transfer during operation. Moreover, fuel cell assemblies can
be employed in many environments, for multiple applications.

A Proton Exchange Membrane (hereinafter "PEM") fuel cell converts the
chemical energy of fuels such as hydrogen and oxidants such as air/oxygen
15 directly into electrical energy. The PEM is a solid polymer electrolyte that
permits the passage of protons (i.e., H^+ ions) from the "anode" side of a fuel cell
to the "cathode" side of the fuel cell while preventing passage therethrough of
reactant fluids (e.g., hydrogen and air/oxygen gases). Some artisans consider the
acronym "PEM" to represent "Polymer Electrolyte Membrane." The direction,
20 from anode to cathode, of flow of protons serves as a basis for labeling an
"anode" side and a "cathode" side of every layer in the fuel cell, and in the fuel
cell assembly or stack.

Usually, an individual PEM-type fuel cell has multiple, generally
transversely extending layers assembled in a longitudinal direction. In the
25 typical fuel cell assembly or stack, all layers which extend to the periphery of the
fuel cells have holes therethrough for alignment and formation of fluid manifolds
that generally service fluids for the stack. As is known in the art, some of the

fluid manifolds distribute fuel (e.g., hydrogen) and oxidant (e.g., air/oxygen) to, and remove unused fuel and oxidant as well as product water from, fluid flow plates which serve as flow field plates for each fuel cell. Also, other fluid manifolds circulate coolant (e.g., water) for cooling.

5 As is known in the art, the PEM can work more effectively if it is wet. Conversely, once any area of the PEM dries out, the fuel cell does not generate any product water in that area because the electrochemical reaction there stops. Undesirably, this drying out can progressively march across the PEM until the fuel cell fails completely. So, the fuel and oxidant fed to each fuel cell are
10 usually humidified. Furthermore, a cooling mechanism is commonly employed for removal of heat generated during operation of the fuel cells.

Flow field plates are commonly produced by any of a variety of processes. One plate construction technique, which may be referred to as "monolithic" style, compresses carbon powder into a coherent mass. Next, the
15 coherent mass is subjected to high temperature processes which bind the carbon particles together, and convert a portion of the mass into graphite for improved electrical conductivity. Then, the mass is cut into slices, which are formed into the flow field plates. Usually, each flow field plate is subjected to a sealing process (e.g., resin impregnation) in order to decrease gas permeation
20 therethrough and reduce the risk of uncontrolled reactions. Typically, flow field channels are engraved or milled into a face of the rigid, resin-impregnated graphite plate. In order to effectively distribute reactant fluid and/or humidification fluid for the PEM, it is desirable that the flow channels remain as open and unclogged as possible.

25 An exemplary configuration for fuel cell membrane hydration and fluid metering is disclosed in International Publication No. WO 99/05740 by Jones and Walsh (entitled "Fuel Cell Membrane Hydration and Fluid Metering," published February 4, 1999, and assigned to Plug Power, L.L.C.), which is hereby incorporated herein by reference in its entirety. In one aspect, a bridge or

cover plate can extend along the face of a fluid flow plate and across the inlets thereof, defining one opening or injection port for each inlet in addition to an input orifice to a fluid manifold. The inlets can receive respective portions of a given stream of reactant fluid for the fuel cell. Each injection port can inject a
5 portion of liquid water directly into its respective flow channel in order to mix its respective portion of liquid water with the corresponding portion of the stream. This serves to hydrate at least corresponding parts of a given membrane of the corresponding fuel cell. The hydration system may be augmented by a metering system, including flow regulators. Each flow regulator can meter an injecting of
10 liquid portions at the plate inlets into a given fluid stream. The bridge or cover plate may be interposed between a gasket and the fluid flow plate, at the inlets thereof.

However, it remains desirable to provide refinements to such membrane hydration and fluid metering as well as further enhancements for fluid service,
15 including enhanced flow plate configuration and fluid manifolding. For instance, it may be desired to eliminate need for a bridge or cover plate, while still offering advantages thereof. For example, it is advantageous to protect inlets for flow channels on a fluid flow plate from intrusion by an adjacent material, such as a gasket. Furthermore, it is desirable to maintain a clamping
20 pressure on a membrane electrode assembly, such as between gaskets adjacent each fluid flow face of a fuel cell. Namely, one would wish to avoid reactant fluid (e.g., gas) on one side of the fuel cell from leaking around an edge of the membrane electrode assembly into the opposite side of the fuel cell. In particular, an insufficient clamping of the membrane electrode assembly may
25 allow flapping thereof in the presence of pressurized reactant fluid flow, which may cause leakage of the reactant fluid at the plate inlets to an opposite side of the fuel cell, with deleterious consequences (e.g., explosion).

Thus, a need exists for an improved mechanism for maintaining open and unclogged, flow channels of a fluid flow plate in a fuel cell assembly. A further

need exists for such a mechanism to promote stability and support for the fuel cell assembly. An additional need exists for fluid flow plates which are shaped to optimize fluid service. A still further need exists for reducing the number of parts for a fuel cell stack, including easing the assembly thereof. Yet another
5 need exists for coordination and cooperation among fluid flow plates in increasing design flexibility, and in providing features for enhanced fluid service and fuel cell assembly operation.

SUMMARY OF THE INVENTION

Pursuant to the present invention, shortcomings of the existing art are
10 overcome and additional advantages are provided through the provision of a fuel cell assembly unit.

In one aspect of the invention, a fuel cell assembly unit includes a first plate and a second plate. The first plate includes a first face and a second face. The first face comprises a flow field face which includes a flow channel thereon.
15 The first plate includes an aperture forming a manifold portion of a manifold for conducting a fluid for a fuel cell assembly. The flow field face includes a formation thereon serving to impede fluid communication on the flow field face between the flow channel and the aperture. The first plate includes an opening extending between the flow channel and the second face. The second plate
20 includes a third face. The third face includes a surface portion forming a passage portion of a flow path between the manifold and the opening.

The formation can serve to provide a seal with a membrane electrode assembly portion. The formation can include a gasketing material portion and/or be adapted to serve as a gasketing material portion. The formation can serve to
25 provide a seal with a gasketing material portion. The formation can resemble a step and/or include a peak.

In yet another aspect of the present invention, a fuel cell assembly unit includes a first plate and a second plate. The first plate includes a first flow field

face which includes a first flow channel thereon. The first plate includes a first aperture forming a first manifold portion of a first manifold for conducting a type of reactant fluid for a fuel cell assembly. A first longitudinal axis of the fuel cell assembly passes through a first port for the first plate. The first port is in fluid communication with the first flow channel and the first manifold. The second plate includes a second flow field face which includes a second flow channel thereon. The second plate includes a second aperture and a third aperture. The second aperture forms a second manifold portion of the first manifold. The third aperture forms a third manifold portion of a second manifold for conducting the type of reactant fluid. A second longitudinal axis of the fuel cell assembly passes through a second port for the second plate. The second port is in fluid communication with the second flow channel and the second manifold. The second plate is formed without a port having the first longitudinal axis pass therethrough and in fluid communication with the second flow channel and the first manifold and/or the second manifold.

The first manifold and the second manifold can comprise a same manifold. The second aperture and the third aperture can comprise a same aperture. The first aperture can form a fourth manifold portion of the second manifold.

The invention further contemplates a method suitable for fuel cell assembly flow field fluid service. A first plate is selected to have a first face and second face. The first face comprises a flow field face which includes a flow field channel thereon. The second face comprises an exterior face. The first plate includes an opening extending between the flow field channel and the exterior face. A second plate is selected to have a third face. The third face includes a surface portion thereon. A fluid portion is conducted along a flow path between a manifold and the flow field channel. The flow path includes the surface portion and the opening.

Thus, the present invention advantageously provides enhanced fluid service for a fuel cell assembly. Further, the invention provides improved configurations for formation of fluid flow plates. Also, coordination and cooperation among fluid flow plates provide geometric features. In addition,
5 there is provided improved sealing of a membrane electrode assembly portion. Metering of humidification fluid is also enabled. Furthermore, a decreased number of components and an easier assembly for a fuel cell stack are included in the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention will be readily understood from the following detailed description of preferred embodiments taken in conjunction with the accompanying drawings in
15 which:

FIG. 1 is a sectional, elevation, side view of one example of a fuel cell assembly incorporating and using the fluid service and design flexibility capabilities of the present invention;

20 **FIG. 2** is a plan view of an outer face of one example of a fluid flow plate of the fuel cell assembly of FIG. 1;

FIG. 3 is a cutaway, sectional, partial, side representation of fluid flow plates serving as flow field plates in a fuel cell of the fuel cell assembly of FIG. 1;

25 **FIG. 4** is a cutaway, sectional, partial, side representation of a flow path between a manifold and a flow channel on a fluid flow face, illustrating the flow path as employing a bridge plate between the fluid flow face and a gasket;

5 **FIG. 5** is a cutaway, sectional, partial, side representation of a flow path between a manifold and a flow channel on a fluid flow face of a fluid flow plate, illustrating the flow path passing along an adjacent fluid flow plate and through an opening in communication with the flow channel;

FIG. 6 is a view similar to **FIG. 5**, further illustrating a peripheral portion of the fluid flow plate providing a gasketing function by interfacing with a membrane electrode assembly portion;

10 **FIG. 7** is an enlarged cutaway, partial, side, sectional representation of an exemplary configuration for the peripheral portion of the fluid flow plate of **FIG. 6**;

FIG. 8 is a cutaway, partial, perspective view of one side of a fluid flow plate, illustrating inlet ports between manifolds and flow channels;

15 **FIG. 9** is a cutaway, partial, perspective view of an opposite side of the fluid flow plate of **FIG. 8**;

FIG. 10 is a cutaway, partial, perspective representation of the fluid flow plate of **FIG. 8** and a second fluid flow plate having cooperating surfaces and configurations for providing fluid service,
20 illustrating inlet ports between manifolds and flow channels;

FIG. 11 is a plan view of an outer face of one example of a fluid flow plate having multiplied fluid manifolds extending therethrough;

FIG. 12 is a plan view of an opposite outer face of the fluid flow plate of **FIG. 11**;

25 **FIG. 13** is a perspective representation of multiple instances of the fluid flow plate of **FIG. 12**, illustrating an exemplary relative positioning of the fluid flow plates for providing an exemplary use of the manifolds and surfaces;

FIG. 14 is a cutaway, partial, perspective view of one side of the fluid flow plate of FIG. 8, illustrating an outlet port between a manifold and flow channels;

5 FIG. 15 is a cutaway, partial, perspective view of an opposite side of the fluid flow plate of FIG. 14; and

FIG. 16 is a cutaway, partial, perspective representation of the fluid flow plates of FIG. 10, illustrating outlet ports between a manifold and flow channels.

BEST MODE FOR CARRYING OUT THE INVENTION

10 In accordance with the principles of the present invention, a fuel cell assembly is provided in which surfaces of multiple fluid flow plates (e.g., flow field plates) are employed in providing fluid service as well as enhancing support in the fuel cell assembly, in addition to increasing design flexibility therefor and easing formation thereof.

15 An example of a fuel cell assembly incorporating and using the novel features of the present invention is depicted in FIG. 1 and described in detail herein.

20 In this exemplary embodiment, a fuel cell assembly 100 includes end plates 102 and 104, insulation layers 106 and 108, and current collector/conductor plates 110 and 112, with a working section 114 therebetween. The working section includes one or more active sections and can include a selected number of cooling sections, as will be understood by those skilled in the art. In one aspect, the one or more active sections can further serve to perform cooling for the fuel cell assembly. A number of structural members
25 116, such as tie-bolt(s), can be employed to join the end plates.

Working section 114 includes a number of layers 118. The layers generally form fluid manifolds 150 for supplying fluids to, removing fluids from, and otherwise communicating and/or servicing fluids as desired within the

working section, as will be appreciated by those skilled in the art. The layers of fuel cell assembly 100 might have applied thereto compressive pressure and/or stress which is approximately equivalent to, preferably, fifty to one thousand pounds per square inch, and, most preferably, two hundred to four hundred pounds per square inch.

Preferably, a plurality of layers 118 form one or more (e.g., one hundred and eight) PEM-type fuel cells 300 (FIG. 3). The construction and utilization of PEM fuel cells is known in the art. By connecting an external load (not shown) between electrical contacts (not shown) of current collector/conductor plates 110 and 112, one can complete a circuit for use of current generated by the one or more PEM-type fuel cells.

One example of a layer 118 of working section 114 is depicted in FIG. 2 as fluid flow plate 200. The plate has a fluid flow face 202 with one or more, for instance, substantially parallel and/or generally serpentine, flow channel(s) 204 thereon. The flow channels receive and transmit one or more fluids through ports 206 and 208 which are in fluid communication with corresponding fluid manifolds 150 and 150'.

In one embodiment, flow channel(s) 204, through formation of solid sidewalls in fluid flow face 202, may have any preselected configuration(s), such as for providing and/or ensuring maximal, even, continuous, appropriate, desired and/or uniform fluid service and/or coverage for active area(s) of membrane electrode assembly 310 (FIG. 3). In one example, land(s) 314, 314' (FIG. 3) may separate adjacent flow channel sections.

As will be understood by those skilled in the art, a given fluid flow plate 200 may be a bipolar, monopolar, combined monopolar (e.g., anode cooler or cathode cooler), or cooling plate. In one example, the fluid flow plate serves as a flow field plate and flow channels 204 conduct fluid which includes reactant fluid for fuel cell assembly 100. The reactant fluid serves as fuel or oxidant for a given fuel cell 300 (FIG. 3). For instance, the flow channels can carry reactant

gas (e.g., a fuel such as hydrogen or an oxidant such as air/oxygen) as well as vapor and/or liquid (e.g., humidification and/or product water), as will be understood by those skilled in the art.

Referring to FIG. 2, fluid flow plate 200 has a number of (e.g.,
5 peripheral) holes 210 therethrough. A number of the holes 210 may cooperate in formation of fluid manifolds, such as fluid manifolds 150, of fuel cell assembly 100. Preferably, the perimeters of layers 118 are formed with minimal amounts of material disposed generally transversely beyond the active extent of working section 114 as well as the fluid manifolds of the fuel cell assembly, as
10 represented in FIG. 2. In one example, the fluid flow plate may be formed with a material such as non-magnetic, austenitic stainless steel. In another example, a material such as titanium may be employed.

In a further example, fluid flow plate 200 may be formed in accordance with the principles of U.S. Application Serial No. 09/054,670 by Carlstrom
15 (entitled "Easily-Formable Fuel Cell Assembly Fluid Flow Plate Having Conductivity and Increased Non-Conductive Material," filed April 3, 1998, and assigned to Plug Power, L.L.C.), which is hereby incorporated herein by reference in its entirety. In one aspect, the fluid flow plate may include conductive, non-conductive, injection-moldable and compliant portions. In
20 another aspect, the fluid flow plate may include hole(s) 801 (FIGS. 8-10 and 14-20) for receiving structural members 116 (FIG. 1) therethrough.

In one embodiment, gasketing material or gaskets 304, 304' (FIG. 3) may be employed to seal peripheral holes 210 (FIG. 2), and may cooperate with other portions of layers 118 in formation of the fluid manifolds. Referring to FIG. 3, a
25 given gasket 304, 304' might take the form of, for instance, a frame gasket made from a polytetrafluoroethylene ("PTFE") material manufactured by E. I. DuPont de Nemours Company and sold under the trademark TEFLON®. In another embodiment, O-ring gasket(s) might be employed.

For purposes of illustration, FIG. 3 depicts fuel cell 300 with fluid flow plates 200 and 200' serving as flow field plates. In particular, flow field plate 200 might serve as an anode side of the fuel cell, and flow field plate 200' might serve as a cathode side of the fuel cell. That is, face 202 might comprise an anode face, and face 202' might comprise a cathode face. For instance, flow channels 204 might carry hydrogen, as fuel, and humidification water (vapor and/or liquid). Further, flow channels 204' might carry air/oxygen, as oxidant, as well as humidification water (vapor and/or liquid) and/or product water (vapor and/or liquid), as will be understood by those skilled in the art.

Fuel cell 300 includes membrane or solid electrolyte 306. Preferably, the solid electrolyte 306 comprises a solid polymer electrolyte made using a polymer such as a material manufactured by E. I. DuPont de Nemours Company and sold under the trademark NAFION®. Further, an active electrolyte such as sulfonic acid groups might be included in this polymer. In another example, the solid polymer electrolyte might be formed with a product manufactured by W.L. Gore & Associates (Elkton, MD) and sold under the trademark GORE-SELECT®. Moreover, catalysts 308 and 308' (e.g., platinum), which facilitate chemical reactions, are applied to the anode and cathode sides, respectively, of the solid polymer electrolyte. This unit can be referred to as a "membrane electrode assembly" (hereinafter "MEA") 310. The MEA might be formed with a product manufactured by W.L. Gore & Associates and sold under the trade designation PRIMEA 5510-HS.

MEA 310 is sandwiched between anode and cathode gas diffusion layers (hereinafter "GDLs") 312 and 312', respectively, which may be formed with a resilient and conductive material such as carbon fabric, carbon fiber paper, carbon cloth or carbon paper.

In one embodiment of a gas diffusion layer (hereinafter "GDL") 312, 312', porous carbon cloth or paper is infused with a slurry of carbon black and sintered with TEFLON® material. The anode and cathode GDLs serve as

electrochemical conductors between corresponding catalyzed sites of solid polymer electrolyte 306 and the fuel (e.g., hydrogen) and oxidant (e.g., air/oxygen) which each flow in anode and cathode flow channels 204 and 204', respectively. Further, the GDLs also present to the surfaces of MEA 310 a
5 combination of microscopic porosity and macroscopic porosity. Microscopic porosity allows reactant gas molecules to pass generally longitudinally from the flow channels to a surface of the MEA. Macroscopic porosity allows product water formed at the cathode surface of the MEA to be removed therefrom by flowing generally longitudinally into the cathode flow channels, to prevent
10 flooding of the catalyst particles.

In one example, deionized water might be added to a given reactant gas stream conducted by flow channel(s) 204, 204'. The water would desirably serve to humidify membrane 306. In an exemplary embodiment, humidification of reactant fluid may occur in accordance with the principles of the above-
15 incorporated International Publication No. WO 99/05740. In an alternative embodiment, a reactant fluid (e.g., gas) stream may be humidified in any of a variety of ways, as will be understood by those skilled in the art.

Referring to FIG. 3, it is desirable to provide maximal conductivity between catalyst 308 and electrical contact position(s) on face 202, and between
20 catalyst 308' and electrical contact position(s) on face 202', as will be appreciated by those skilled in the art. That is, it is advantageous to maximize conductivity between the anode face of MEA 310 and the electrical contact position(s) on the anode face 202, and between the cathode face of the MEA and the electrical contact position(s) on the cathode face 202'.

25 For example, still referring to FIG. 3, portions of lands 314 and 314' may serve as electrical contact positions on corresponding anode and cathode faces 202 and 202'. The land(s) 314, 314' may be formed, for instance, with a material such as non-magnetic, austenitic stainless steel. In another example, a material such as titanium may be employed. Additional description of possible electrical

contact positions is provided in the above-incorporated U.S. Application Serial No. 09/054,670.

Referring further to FIG. 3, GDL 312 is located between lands 314 and (e.g., catalyst 308) the anode side of MEA 310, and GDL 312' is located between
5 the lands 314' and (e.g., catalyst 308') the cathode side of the MEA.

Now referring to FIG. 4, bridge or cover plate 402 may be employed between gasket 304 and flow channel(s) 204. An exemplary configuration for such a bridge or cover plate is disclosed in the above-incorporated International Publication No. WO 99/05740. In one aspect, the bridge or cover plate may
10 serve to maintain open and unclogged certain port(s) 206 between manifold 150 and the flow channels, such as for flow path 401. For instance, the bridge or cover plate may serve to prevent intrusion of the gasket into the ports (e.g., under compression of fuel cell assembly 100).

In another aspect, again referring to FIG. 4, bridge or cover plate 402 may
15 serve to cooperate with opposite gasket 304' and opposite plate 200' in maintaining a clamping or sealing pressure on MEA 310, thereby advantageously preventing unwanted leakage or seeping of, for instance, reactant fluid in a fuel cell. For example, one typically would wish to avoid leakage of anode reactant gas from fluid manifold 150, between the gasket 304' and the MEA 310, and
20 directly to the cathode side of the MEA, as well as any leakage or seeping of cathode reactant gas, from a fluid manifold, between the gasket 304 and the MEA 310, and directly to the anode side of the MEA. Such leakage or seeping may have deleterious consequences for operation of fuel cell assembly 100, such as an explosion therein or thereof, as will be appreciated by those skilled in the art.

25 However, inclusion of bridge or cover plate 402 requires manufacturing of the same, as well as careful positioning thereof during assembly of fuel cell stack 100. In one aspect, it may be desirable to eliminate expense and/or effort associated with and/or attributable to the separate part or piece of the bridge or

cover plate, through a configuration which nevertheless provides the advantageous functions of the bridge or cover plate.

In one example of such a configuration, referring to FIG. 5, port 206 may provide fluid communication between flow channel(s) 204 on fluid flow face 202 and fluid manifold 150 by employing opening 858 between the fluid flow face
5 202 and backside face 504. Moreover, the port may comprise flow path 501 between the manifold and the flow channel employing, for instance, first surface 506 on the backside face, second surface 508 on additional fluid flow plate 510, third surface 512 on additional gasket 514, and/or other surface(s).

Still referring to FIG. 5, fluid flow face 202 may include formation 516
10 serving, in one aspect, to impede and/or prevent fluid communication on the fluid flow face 202 directly from manifold 150, past gasket 304, and to flow channel(s) 204. The formation may further serve to abut the gasket 304 and maintain sealing or clamping pressure for MEA 310 against and/or with opposite
15 gasket 304' in abutment with opposite face 202' of opposite fluid flow plate 200', such as for preventing undesired leakage. In one aspect, the formation may resemble a step. For example, the formation may serve to eliminate need for a separate bridge or cover plate or piece, and advantageously reduce the number of parts in fuel cell stack 100, thereby easing manufacturing and assembling thereof.

For explanatory purposes, port 206 may be considered to be an inlet port,
20 where those skilled in the art will appreciate how description herein of such an inlet port may apply and/or be extended and/or modified to apply to certain aspects of an outlet port (e.g., one may for illustrative purposes consider port 208 of FIG. 2 to be such an outlet port).

In a further aspect, referring to FIG. 6, formation 516 may provide a
25 gasketing function. For instance, the formation may directly seal with MEA 310. In one example, the formation may comprise feature(s) of fluid flow plate 200 formed in accordance with the principles of the above-incorporated U.S. Application No. 09/054,670. For instance, the formation may comprise physical

and/or geometric feature(s) of non-conductive, compliant, and/or injection-molded material(s). In one example, referring to FIG. 7, the formation may include peak(s) 518, such as for enhancing sealing with the MEA.

An exemplary embodiment of port(s) 206 as including reactant inlet port 802 and humidification inlet port 804 is now described with reference to FIGS. 8-9.

Referring to FIGS. 8-9, fluid flow plate 200 may include aperture(s) 850 and/or 852 extending therethrough. In one example, the aperture 850 may form a portion of reactant fluid manifold 854. The reactant fluid manifold may carry reactant fluid for a number of fuel cells 300 of fuel cell assembly 100. For instance, the aperture 852 may form a portion of humidification fluid manifold 856. The humidification fluid manifold may carry humidification fluid to be added to the reactant fluid provided through the reactant fluid manifold, such as for humidification of MEA 310. For instance, the reactant fluid may comprise a fuel such as hydrogen or an oxidant such as air/oxygen. Further, the humidification fluid may comprise a liquid such as deionized water.

Still referring to FIGS. 8-9, in an exemplary configuration for port(s) 802, fluid flow plate 200 may include opening(s) 858 and/or opening(s) 860. The opening 858 may participate in communication of reactant fluid between reactant fluid manifold 854 and flow channel(s) 204. The openings 860 may participate in communication of humidification fluid between humidification fluid manifold 856 and the flow channels 204.

Further referring to FIGS. 8-9, fluid flow plate 200 may include formation(s) 862 and/or 864. The formation 862 may be located between reactant fluid manifold 854 and opening 858. Also, the formation 864 may be located between humidification fluid manifold 856 and opening(s) 860.

With respect to exemplary reactant fluid flow, again referring to FIGS. 8-9, formation 862 may resemble a step on fluid flow face 202 serving to impede and/or prevent fluid communication between reactant fluid manifold 854, directly

on the fluid flow face 202, and into flow channel(s) 204. As described herein, reactant fluid may be communicated between the reactant fluid manifold and the flow channels by passing on surface(s) between the flow channels and the reactant fluid manifold, including surface(s) not located on the fluid flow face

5 202. For instance, a flow path between the reactant fluid manifold and the flow channels may pass along surface 506 of face 504. In one example, the formation 862 may include passage(s) 866 for participating in fluid flow between the reactant fluid manifold 854 and opening 858. In one aspect, the formation 862 may include rib(s) 868 between instances of the passages 866.

10 With respect to exemplary humidification fluid flow, still referring to FIGS. 8-9, formation 864 may resemble a step on fluid flow face 202 serving to impede and/or prevent fluid communication on the fluid flow face directly between humidification fluid manifold 856 and flow channel(s) 204. Further, the formation 864 may on face 504 include passage(s) 870 between the

15 humidification fluid manifold and opening(s) 860. In one example, the openings 860 may resemble flow regulators and/or metering orifices such as are disclosed in the above-incorporated International Publication No. WO 99/05740. For instance, the openings 860 may serve to atomize humidification liquid to be added to reactant fluid flow streams in the flow channels 204.

20 In one aspect, referring to FIGS. 8-9, formation(s) 862 and/or 864 may serve to obviate the previous need(s) for bridge or cover plate(s) or piece(s). In particular, the step(s), optionally including peak(s) 518, for fluid flow face 202, may serve to provide sealing and/or clamping surface(s) with layer(s) 118 such as portion(s) of gasket(s) 304 and/or MEA(s) 310. Furthermore, flow path(s) on

25 and/or adjacent to face 504, may serve to eliminate need for separate bridge or cover plate(s) or/or piece(s), while providing fluid communication between flow channel(s) 204 and reactant fluid manifold 854 and/or humidification fluid manifold 856.

As will be appreciated by those skilled in the art, port(s) 802 may include a plurality of openings 858 extending through fluid flow plate 200, analogously to the exemplary depiction in FIG. 9 of a plurality of openings 860 illustratively comprising port(s) 804.

5 For explanatory purposes, FIGS. 8-10 and 14-16 illustrate exemplary cooperating configuration(s) among fluid flow plates 200 and 510.

As can be understood through examination of FIGS. 10 and 16, fluid flow plates 200 and 510, in an exemplary configuration, include similar feature(s), some of which are aligned and others of which are offset, to provide cooperating
10 surface(s), as described herein. A number of features of fluid flow plate 200 have already been described in detail above, and similar features of fluid flow plate 510 are now described.

Referring to FIG. 10, port(s) 206 (FIG. 2) may include reactant inlet port 1802 and humidification inlet port 1804, which may be analogous to ports 802
15 and 804, respectively. In particular, fluid flow plate 510 may include aperture(s) 1850 and/or 1852 extending therethrough. In one example, the aperture 1850 may form a portion of reactant fluid manifold 854. For instance, the aperture 1852 may form a portion of humidification fluid manifold 856. The fluid flow plate 510 may include opening(s) 1858, and/or opening(s) comparable to
20 opening(s) 860 (FIG. 9). The opening 1858 may participate in communication of reactant fluid between the reactant fluid manifold 854 and flow channel(s) 1204. The above-mentioned openings analogous to the openings 860, may participate in communication of humidification fluid between the humidification fluid manifold 856 and the flow channels 1204.

25 Again referring to FIG. 10, fluid flow plate 510 may include formation(s) 1862 and/or 1864, which may be similar to formations 862 and 864, respectively. For instance, the formation 1862 may be located between reactant fluid manifold 854 and opening 1858.

Returning to FIG. 10, fluid flow plate 200 may include aperture 850 forming a portion of reactant fluid manifold 854. Fluid flow plate 510 may include aperture 1850 forming another portion of the same reactant fluid manifold 854. In one aspect, the apertures 850 and 1850 may have a first
5 longitudinal axis of fuel cell assembly 100 passing therethrough. For instance, the apertures 850 and 1850 may include portions thereof at locations sharing same approximate transverse offset(s) with respect to a certain longitudinal axis of the fuel cell assembly.

In another aspect, referring again to FIG. 10, port 802 for fluid flow plate
10 200 may provide fluid communication between reactant fluid manifold 854 and flow channel(s) 204 on fluid flow face 202. In a further aspect, port 1802 may provide fluid communication between the reactant fluid manifold 854 and flow channel(s) 1204 on face 1202 of fluid flow plate 510. In one example, the ports 802 and 1802 have different longitudinal axes of fuel cell assembly 100 passing
15 therethrough. In a still further aspect, opening 858 of the fluid flow plate 200 and surface 508 of fluid flow plate 510 have a same longitudinal axis of the fuel cell assembly passing therethrough. In particular, the surface 508 may participate in providing a flow path between the reactant fluid manifold 854 and the flow channel(s) 204 on the fluid flow face 202, as described herein. In yet another
20 aspect, fluid flow face 202 may include surface 1508. The surface 1508 and opening 1858 of plate 510, in one example, have a same longitudinal axis of the fuel cell assembly passing therethrough. Where multiple instances of fluid flow plates 200 and 510 are positioned one behind the other, various instance(s) of surface 1508 may participate in providing fluid communication between reactant
25 fluid manifold 854 and flow channel(s) 1204, similarly to the above-described exemplary function provided by surface 508 between the reactant fluid manifold and the flow channels 204, as will be appreciated by those skilled in the art.

Still referring to FIG. 10, it may be observed that fluid flow plate 510 has port 1802 located so a longitudinal axis of fuel cell assembly 100 passing through

the port 1802 passes through surface 1508 of fluid flow face 202, but does not pass through port 802 of the fluid flow face 202. Further, the fluid flow plate 200 has the port 802 located so a longitudinal axis of the fuel cell assembly passing therethrough also passes through surface 508 of fluid flow face 1202, but does not pass through the port 1802. That is, the present invention includes selected alignment(s) and unalignment(s). Therefore, the surface 508 may participate in providing fluid communication between reactant fluid manifold 854 and flow channels 204 without interfering with reactant fluid communication between the reactant fluid manifold and flow channels 1204, as described herein. Similarly, interference with humidification fluid service may be avoided.

Referring further to FIG. 10, formation 862 may cooperate with surface 508 in providing a mechanism allowing reactant fluid communication between reactant fluid manifold 854 and flow channels 204, in addition to providing for MEA 310 clamping and/or sealing previously provided through an additional bridge or cover plate or piece. Comparable advantage(s) may be provided through positioning of formation 1862 between the reactant fluid manifold and flow channels 1204, as well as coordination with a particular instance of surface 1508 (e.g., located on an instance of fluid flow plate 200 positioned behind fluid flow plate 510), as will be appreciated by those skilled in the art.

In a still further aspect and as can be understood through examination of FIGS. 8-9 in conjunction with FIG. 10, fluid flow plate 510 may include surface 2508 having a longitudinal axis of fuel cell assembly 100 passing therethrough, which longitudinal axis may also pass through port 804 for fluid communication between humidification fluid manifold 856 and flow channel(s) 204. The surface 2508 may participate in providing flow path(s) between the humidification fluid manifold and the flow channels 204, in cooperation with formation 864, as described herein. Also, fluid flow plate 510 may have port 1804 providing fluid communication between the humidification fluid manifold and flow channel(s) 1204, located so a longitudinal axis of the fuel cell assembly, different from the

above-mentioned longitudinal axis passing through port 804 and surface 2508, passes through the port 1804 and surface 3508 of fluid flow face 202. As will be appreciated by those skilled in the art, an instance of surface 3508 located on an instance of fluid flow plate 200 positioned behind fluid flow plate 510, may
5 cooperate with formation 1864 in providing a flow path between humidification fluid manifold 856 and flow channels 1204, while obviating the previous need for a bridge or cover plate or piece, as described herein.

In one aspect, referring to FIGS. 8-10 and 14-16, port 802 may exemplify an inlet port between reactant fluid manifold 854 and flow channel(s) 204, and
10 port 1802 may exemplify an inlet port between the reactant fluid manifold and flow channel(s) 1204. Further, port 804 may serve to illustrate an inlet port between humidification fluid manifold 856 and the flow channels 204, and port 1804 may serve to illustrate an inlet port between the humidification fluid manifold and the flow channels 1204. As will be appreciated by those skilled in
15 the art, at corresponding outlet ports for the flow channels 204 and 1204, in one example, certain ports may be provided as outlet ports. Namely, at discharge of reactant fluid, product fluid, and/or humidification fluid, it may often be the case that a single exit manifold with a single exit port thereto from flow channel(s) 204, 1204 will suffice, as will be understood by those skilled in the art. Still,
20 formations such as formations 862 and 1862 may be employed at such outlet ports in order to further obviate need for bridge or cover plate(s), such as through configuration(s) which place the outlet ports on (e.g. successive) plates along different longitudinal axes of the fuel cell assembly, with surfaces such as surfaces 508 and 1508 being located for contribution in providing flow paths
25 between the exit manifold and the flow channels, as described herein.

Turning now to FIGS. 11-12, fluid flow plate 1100 includes multiple apertures serving to form respective portions of corresponding fluid manifolds for fuel cell assembly 100. It is understood that various feature(s) of fluid flow plate 1100 may allow and/or be modified to allow numerous uses. For

illustrative purposes, a specific application of the fluid flow plate 1100 is now presented.

In one example, referring to FIGS. 11-12, fluid flow plate 1100 includes aperture 1102 forming a portion of an entrance fuel manifold 1104 lacking a port
5 for face 1106 or face 1108 between the entrance fuel manifold 1104 and flow channel area 1110 on fluid flow face 1106 or flow channel area 1112 on fluid flow face 1108. The fluid flow plate 1100 includes aperture 1114 forming a portion of entrance fuel manifold 1116 in fluid communication with port(s) 1118, providing fluid communication between the flow channel area 1110 on the fluid
10 flow face 1106 and the entrance fuel manifold 1116. Furthermore, the fluid flow plate 1100 includes aperture 1120 forming a portion of exit fuel manifold 1122 lacking a port between the same and the flow channel area 1110 or the flow channel area 1112. Moreover, the fluid flow plate 1100 includes aperture 1124 forming a portion of exit fuel manifold 1126 in fluid communication with port
15 1128, providing fluid communication between the flow channel area 1110 and the exit fuel manifold 1126.

Still referring to FIGS. 11-12, fluid flow plate 1100 includes aperture 1130 forming a portion of entrance oxidant manifold 1132 lacking a port providing fluid communication between the same and flow channel area 1110 or
20 flow channel 1112. Aperture 1134 forms a portion of entrance oxidant manifold 1136 in fluid communication with port 1138, providing fluid communication between flow channel area 1112 and the entrance oxidant manifold 1136. Aperture 1140 forms a portion of exit oxidant manifold 1142 lacking a port between the same and the flow channel area 1110 or the flow channel area 1112.
25 Aperture 1144 forms a portion of exit oxidant manifold 1146 in fluid communication with port 1148, providing fluid communication between flow channel area 1112 and the exit oxidant manifold 1146.

Further referring to FIGS. 11-12, aperture 1150 forms a portion of humidification fluid manifold 1152. The humidification fluid manifold 1152 is

in fluid communication with port 1154, providing fluid communication between the humidification fluid manifold 1152 and port 1118, in fluid communication with flow channel area 1110. Furthermore, the humidification fluid manifold 1152 is in fluid communication with port 1156, which is in fluid communication with port 1138 providing fluid communication with flow channel area 1112. Aperture 1158 forms a portion of humidification fluid manifold 1160 lacking a port providing fluid communication between the humidification fluid manifold 1158 and the flow channel area 1110 or the flow channel area 1112.

So, in this exemplary implementation illustrated in FIGS. 11-12, fuel and humidification fluid may enter flow channel area 1110 from port 1118, and exit the flow channel area 1110 through port 1128. Furthermore, oxidant and humidification fluid may enter flow channel area 1112 from port 1138, and exit the flow channel area 1112 through the port 1148.

Again referring to FIGS. 11-12, fluid flow plate 1100 is illustrated, for explanatory purposes, with four corners labeled A, B, C, and D. These labels will now be employed in describing an exemplary relative rotation among multiple instances of the fluid flow plate 1100, for advantage(s) such as enhanced design flexibility.

Referring now to FIG. 13, multiple instances of fluid flow plate 1100 are illustrated with reference labels A, B, C, and D indicating an exemplary relative orientation among the fluid flow plates. As can be understood through examination of FIGS. 11-12 in conjunction with FIG. 13, the multiple instances of apertures for entrance and exit of fluids are used at varying relative orientations among the multiple fluid flow plates.

For explanatory purposes, FIG. 13 depicts two distinct orientations for fluid flow plate 1100. Those skilled in the art will appreciate further orientation(s) and/or additional feature(s) for the fluid flow plates may be provided. A description of use and reuse of various apertures and manifolds on

different faces of the multiple instances of the fluid flow plate 1100 is now presented.

In one example, referring to FIGS. 11-13, aperture 1114 on first instance 2200 of fluid flow plate 1100 forms a portion of fuel entrance manifold 1116, where port 1118 provides fluid communication between the entrance fuel manifold 1116 and flow channel area 1110. The aperture 1114 on the first instance 2200 of the fluid flow plate 1100 has a first longitudinal axis of fuel cell assembly 100 passing therethrough. Further, the port 1118 on the first instance 2200 of the fluid flow plate 1100 has a second axis of the fuel cell assembly passing therethrough. In accordance with the relative positioning among multiple instances 2200, 2510 of the fluid flow plates 1100 illustrated in FIG. 13, aperture 1102 of second instance 2510 of the fluid flow plate 1100 forms a portion of the entrance fuel manifold 1116 having the first longitudinal axis of the fuel cell assembly passing therethrough. For explanatory purposes, the entrance fuel manifold 1116 of the first instance 2200 of the fluid flow plate 1100, can be considered as comprising entrance fuel manifold 1104 of the second instance 2510 of the fluid flow plate 1100. Furthermore, the second instance 2510 of the fluid flow plate 1100 lacks a port between the entrance fuel manifold 1116 and flow area 1110 on the second instance 2510 of the fluid flow plate 1100 through which the second longitudinal axis otherwise might pass. The second instance 2510 of the fluid flow plate 1100 would receive fuel from port 1118 into flow channel area 1110 at a location having yet a third longitudinal axis of the fuel cell assembly passing therethrough. In this exemplary illustration, the port 1118 on the second instance 2510 of the fluid flow plate 1100 would occur at a location ninety degrees relatively, transversely, and rotationally offset from the port 1118 on the first instance 2200 of the fluid flow plate 1100, as will be appreciated by those skilled in the art.

Having followed the above description of use and reuse of features for multiple instances 2200, 2510 of fluid flow plate 1100 to provide fuel entrance to

the flow field through relative positioning, one can understand, in FIGS. 11-13 as well as in further embodiment(s), how cooperative arrangement of additional feature(s) for various instance(s) of the fluid flow plate 1100 may be utilized.

In one aspect, design flexibility may be enhanced and/or structural choice(s) may be expanded in accordance with the principles of the present invention. For instance, by multiplying the number of reactant fluid manifolds and selectively providing ports between a certain fluid manifold and only a subset (e.g., alternate or staggered ones) of an entire set of fluid flow plates in fuel cell assembly 100, the certain fluid manifold need not be as large as it would need to be in order to service the entire set of fluid flow plates in the fuel cell assembly. So, a certain aperture through a particular fluid flow plate forming a portion of the certain fluid manifold may be made smaller. For example, such a decrease in space consumption may allow addition and/or rearrangement of further feature(s) for the fluid flow plate and/or fuel cell assembly. In another aspect, the decrease in space consumption may allow a local decrease in dimension for the fluid flow plate and/or the fuel cell assembly. Similar advantage(s) may result with analogous multiplication for any type of fluid manifold and/or apertures therefor, including, for example, entrance, exit, fuel, oxidant, and/or humidification fluid manifolds and/or apertures therefor.

As will be appreciated by those skilled in the art feature(s) characteristic(s) and/or advantage(s) of the fluid flow plates described herein in any exemplary embodiment, may be applied and/or extended to any embodiment in accordance with the principles of the present invention.

In accordance with the principles of the subject invention, flow channel(s) may be formed with variable cross section(s). Where a plurality of flow channels carry certain fluid on a given fluid flow face between entrance and exit fluid manifolds, each of the plurality of flow channels is preferably formed having substantially the same length. By designing the flow channels to have substantially identical length, one largely prevents variance in pressure drop

among the flow channels, thereby promoting uniform and equal flow as well as superior overall performance. Further, any variance in cross-section along a given flow channel, is preferably substantially duplicated for companion flow channel(s) on the same fluid flow face which carry the same fluid for a same fuel
5 cell.

A given fluid flow plate of the present invention which conducts fluids on both faces might be configured so the fluids have, for example, parallel flow, counter flow, and/or perpendicular flow among various (e.g., generally serpentine) flow channels. In particular, a parallel flow configuration might
10 generally transversely align flow on the opposing faces by positioning corresponding first and second inlets at opposite sides of a first corner of the plate, and corresponding first and second outlets at opposite sides of a generally diametrically opposed second corner of the plate. Further, a counter flow design might provide flow in generally transversely opposite directions on the opposing
15 faces by placing first inlet(s) and second outlet(s) at opposite sides of a first corner of the plate, and first outlet(s) and second inlet(s), respectively, at opposite sides of a generally diametrically opposed second corner of the plate. Moreover, perpendicular flow might entail flow channels on opposite sides of a plate oriented crosswise with respect to each other. Any variation(s), combination(s),
20 and/or modification(s) of these concept(s) may be provided with any flow channel(s) and/or flow channel section(s).

Operation of a fuel cell assembly of the present invention can include periods or intervals of action and inaction, such as an active use followed by idling. Also, the fuel cell assembly can be employed for varied (e.g., automotive
25 to aerospace to industrial to residential) applications, in various environments.

Numerous alternative embodiments of the present invention exist. Fluid flow plate 200 and/or fluid manifold(s) 150, 150' could serve any desired function with any appropriate orientation, shape, and/or formation in any position of fuel cell assembly 100. Further, fluid flow face 202 could easily have any

number of flow channels 204. Any flow channel 204 could easily have any appropriate shape or structure. Also, flow channel(s) 204 could easily be configured to deviate, to any desired degree, from parallel alignment and/or serpentine design. Moreover, any of port(s) 206 and/or port(s) 208 might employ
5 any mechanism for fluid communication between appropriate flow channel(s) 204 and fluid manifold(s) 150, 150'. Design choices permit variation in construction technique(s) and/or material(s) for any portion of fluid flow plate 200 and/or fuel cell assembly 100. Furthermore, fluid flow plate(s) 200 could easily be employed in any appropriate type(s) of fuel cell(s). Additionally,
10 working section 114 could easily include any desired type(s) of fuel cell(s).

Although preferred embodiments have been depicted and described in detail herein, it will be apparent to those skilled in the relevant art that various modifications, additions, substitutions and the like can be made without departing from the spirit of the invention and these are therefore considered to be within the scope of the invention as defined in the following claims.

CLAIMS

What is claimed is:

1. A fuel cell assembly (100) unit, comprising:
a first plate (200) including a first face (202) and a second face (504) directed opposite to said first face, said first face comprising a flow field face including a flow channel (204) thereon, said first plate
5 including an aperture (850) forming a manifold portion of a manifold (854) for conducting a fluid for said flow channel (204), characterized by:
said flow field face including a formation (516, 862) thereon serving to impede fluid communication on said flow field face between said aperture (850) and said flow channel (204), said first plate including
10 an opening (858) separate from said aperture (850) and extending between said flow channel (204) and said second face (504); and
a second plate (510) including a third face (1202) for positioning adjacent said second face (504) of said first plate (200), said third face including a surface portion (508) forming a passage portion of a flow path
15 (501) below said formation (516, 862) between said manifold (854) and said opening (858).
2. The unit of claim 1, wherein at least one of said first face (202), said second face (504), and said third face (1202) comprises an exterior face.
3. The unit of claim 1, wherein said formation (516) serves to provide a seal with a membrane electrode assembly (310) portion.
4. The unit of claim 1, wherein said formation (516) at least one of includes a gasketing material portion and is adapted to serve as a gasketing material portion.

5. The unit of claim 1, wherein said formation (516) serves to provide a seal with a gasketing material (304) portion.

6. The unit of claim 1, wherein said surface portion (508) comprises a first surface portion, wherein said passage portion comprises a first passage portion, and wherein said second face (504) includes a second surface portion (506) forming a second passage portion of said flow path (501).

7. The unit of claim 6, wherein said flow path (501) comprises a first flow path, and wherein said second surface portion (506) forms a third passage portion of a second flow path between said manifold (854) and an opening extending between said second face (504) and a flow channel (204) on said flow field face.

8. The unit of claim 7, wherein said first flow path and said second flow path provide fluid communication between said manifold (854) and a same opening (858) extending between said second face (504) and at least one flow channel (204) on said flow field face.

9. The unit of claim 7, wherein said second surface portion (506) includes a support (868) located between said second passage portion and said third passage portion.

10. The unit of claim 1, wherein said formation (516) at least one of resembles a step and includes a peak (518).

11. The unit of claim 1, wherein said aperture (850) comprises a first aperture, wherein said manifold portion comprises a first manifold portion, and

wherein said second plate (510) includes a second aperture (1850) forming a second manifold portion of said manifold (854).

12. The unit of claim 1, wherein said aperture (850) comprises a first aperture, wherein said manifold (854) comprises a first manifold, wherein said manifold portion comprises a first manifold portion, wherein said opening (858) comprises a first opening, wherein said formation (516) comprises a first formation, wherein said surface portion (508) comprises a first surface portion, wherein said passage portion comprises a first passage portion, wherein said flow path (501) comprises a first flow path;
- wherein said first plate (200) includes a second aperture forming a second manifold portion of a second manifold for conducting said fluid, wherein said flow field face includes a second formation thereon serving to impede fluid communication on said flow field face between said flow channel (204) and said second aperture, wherein said first plate (200) includes a second opening extending between said flow channel (204) and said second face (504);
- wherein said third face (1202) includes a second surface portion forming a second passage portion of a second flow path between said second manifold and said second opening.

13. The unit of claim 1, wherein said aperture (850) comprises a first aperture, wherein said manifold portion comprises a first manifold portion, wherein said manifold (854) comprises a first manifold, wherein said fluid comprises a first fluid, wherein said formation (516) comprises a first formation (862), wherein said opening (858) comprises a first opening, wherein said surface portion (508) comprises a first surface portion, wherein said passage portion comprises a first passage portion, wherein said flow path (501) comprises a first flow path;

10 wherein said first plate (200) includes a second aperture (852),
said second aperture forming a second manifold portion of a second
manifold (856) for conducting a second fluid for said fuel cell assembly
(100), wherein said flow field face includes a second formation (864)
thereon serving to impede fluid communication on said flow field face
between said flow channel (204) and said second aperture (852), wherein
15 said first plate (200) includes a second opening (860) extending between
said flow channel (204) and said second face (504);

 wherein said third face (1202) includes a second surface portion
(2508) forming a second passage (870) portion of a second flow path
between said second manifold (856) and said second opening (860).

14. The unit of claim 1, wherein said flow field face (202) comprises
a first flow field face, wherein said aperture (850) comprises a first aperture,
wherein said manifold portion comprises a first manifold portion, wherein said
manifold (854) comprises a first manifold, wherein said fluid comprises a type of
5 fluid for said fuel cell assembly (100), a first longitudinal axis of said fuel cell
assembly passing through said opening (858);

 wherein said first plate (200) includes a second aperture, said
second aperture forming a second manifold portion of a second manifold
for conducting said type of fluid;

10 wherein said third face (1202) comprises a second flow field face,
said second flow field face including a second flow channel (1204)
thereon, wherein said second plate (510) includes a third aperture, said
third aperture forming a third manifold portion of said second manifold, a
second longitudinal axis of said fuel cell assembly (100) passing through
15 a port (1802) for said second plate, said port in fluid communication with
said second flow channel (1204) and said second manifold.

15. A fuel cell assembly unit, comprising:

a first plate (200) including a first flow field face (202), said first flow field face including a first flow channel (204) thereon, said first plate including a first aperture (850), said first aperture forming a first manifold portion of a first manifold (854) for conducting a type of reactant fluid for a fuel cell assembly (100), a first longitudinal axis of said fuel cell assembly passing through a first port (802) for said first plate, said first port in fluid communication with said first flow channel (204) and said first manifold (854); and

a second plate (510) including a second flow field face (1202), said second flow field face including a second flow channel (1204) thereon, said second plate including a second aperture (1850) and a third aperture, said second aperture forming a second manifold portion of said first manifold (854), said third aperture forming a third manifold portion of a second manifold for conducting said type of reactant fluid, a second longitudinal axis of said fuel cell assembly passing through a second port (1802) for said second plate, said second port in fluid communication with said second flow channel (1204) and said second manifold, characterized by:

said second plate formed without a port having said first longitudinal axis pass therethrough and in fluid communication with said second flow channel and at least one of said first manifold and said second manifold.

16. The unit of claim 15, wherein said first manifold and said second manifold comprise a same manifold (854).

17. The unit of claim 15, wherein said second aperture and said third aperture comprise a same aperture (1850).

18. The unit of claim 17, wherein said first aperture forms a fourth manifold portion of said second manifold.

19. The unit of claim 15, wherein said second flow field face (1202) includes a formation (508) thereon serving to impede fluid communication on said second flow field face between said second flow channel (1204) and said second aperture (1850), said first longitudinal axis passing through said formation (508).

20. The unit of claim 15, wherein said first plate (200) is formed without a port having said second longitudinal axis pass therethrough and in fluid communication with said first flow channel (204) and at least one of said first manifold (854) and said second manifold.

21. The unit of claim 15, wherein said first plate (200) includes a fourth aperture, said fourth aperture forming a fourth manifold portion of a third manifold for conducting said type of reactant fluid, a third longitudinal axis of said fuel cell assembly passing through a third port for said first plate, said third
5 port in fluid communication with said first flow channel (204) and said third manifold; and

wherein said second plate (510) includes a fifth aperture, said fifth aperture forming a fifth manifold portion of a fourth manifold for conducting said type of reactant fluid, a fourth longitudinal axis of said
10 fuel cell assembly passing through a fourth port for said second plate, said fourth port in fluid communication with said second flow channel (1204) and said fourth manifold.

22. The unit of claim 21, wherein said second plate (510) is formed without a port having said third longitudinal axis pass therethrough and in fluid

communication with said second flow channel (1204) and at least one of said third manifold and said fourth manifold.

23. The unit of claim 21, wherein said third manifold and said fourth manifold comprise a same manifold.

24. The unit of claim 15, wherein said first plate (200) includes an other face (504), wherein said first plate includes an opening (858) extending between said first flow channel (204) and said other face, wherein said second flow field face (1202) includes a surface portion (508) forming a first passage
5 portion of a flow path (501) between said first manifold (854) and said opening, wherein said first port (802) comprises at least one of said opening (858) and a second passage portion of said flow path (501).

25. The unit of claim 15, wherein said first flow field face (202) includes a formation (862) thereon serving to impede fluid communication on said first flow field face between said first flow channel (204) and said first aperture (850).

26. The unit of claim 15, wherein said first plate (200) includes a fourth aperture (852), said fourth aperture forming a fourth manifold portion of a third manifold (856) for conducting a humidification fluid for said fuel cell
5 assembly (100), a third longitudinal axis of said fuel cell assembly passing through a third port (804) for said first plate, said third port in fluid communication with said first flow channel (204) and said third manifold (856);
and

wherein said second plate (510) includes a fifth aperture and a sixth aperture, said fifth aperture forming a fifth manifold portion of said third
10 manifold, said sixth aperture (1752) forming a sixth manifold portion of a fourth

manifold for conducting said humidification fluid, a fourth longitudinal axis of said fuel cell assembly passing through a fourth port (1804) for said second plate, said fourth port in fluid communication with said second flow channel (1204) and said fourth manifold.

27. The unit of claim 26, wherein said second plate (510) is formed without a port having said third longitudinal axis pass therethrough and in fluid communication with said second flow channel (1204) and at least one of said third manifold and said fourth manifold.

28. The unit of claim 15, wherein said type of reactant fluid comprises a first type of reactant fluid, wherein said first plate (200) includes a third flow field face (504), said third flow field face including a third flow channel thereon;

5 wherein said first plate (200) includes a fourth aperture, said fourth aperture forming a fourth manifold portion of a third manifold for conducting a second type of reactant fluid for said fuel cell assembly, a third longitudinal axis of said fuel cell assembly passing through a third port for said first plate, said third port in fluid communication with said third flow channel and said third manifold;

10 wherein said second plate (510) includes a fourth flow field face, said fourth flow field face including a fourth flow channel thereon;

wherein said second plate (510) includes a fifth aperture and a sixth aperture, said fifth aperture forming a fifth manifold portion of said third manifold, said sixth aperture forming a sixth manifold portion of a fourth manifold for conducting said second type of reactant fluid, a fourth longitudinal axis of said fuel cell assembly passing through a fourth port for said second plate, said fourth port in fluid communication with said fourth flow channel and said fourth manifold.

15

29. The unit of claim 28, wherein said second plate (510) is formed without a port having said third longitudinal axis pass therethrough and in fluid communication with said fourth flow channel and at least one of said third manifold and said fourth manifold.

30. A fuel cell assembly (100) flow field fluid service method, comprising:

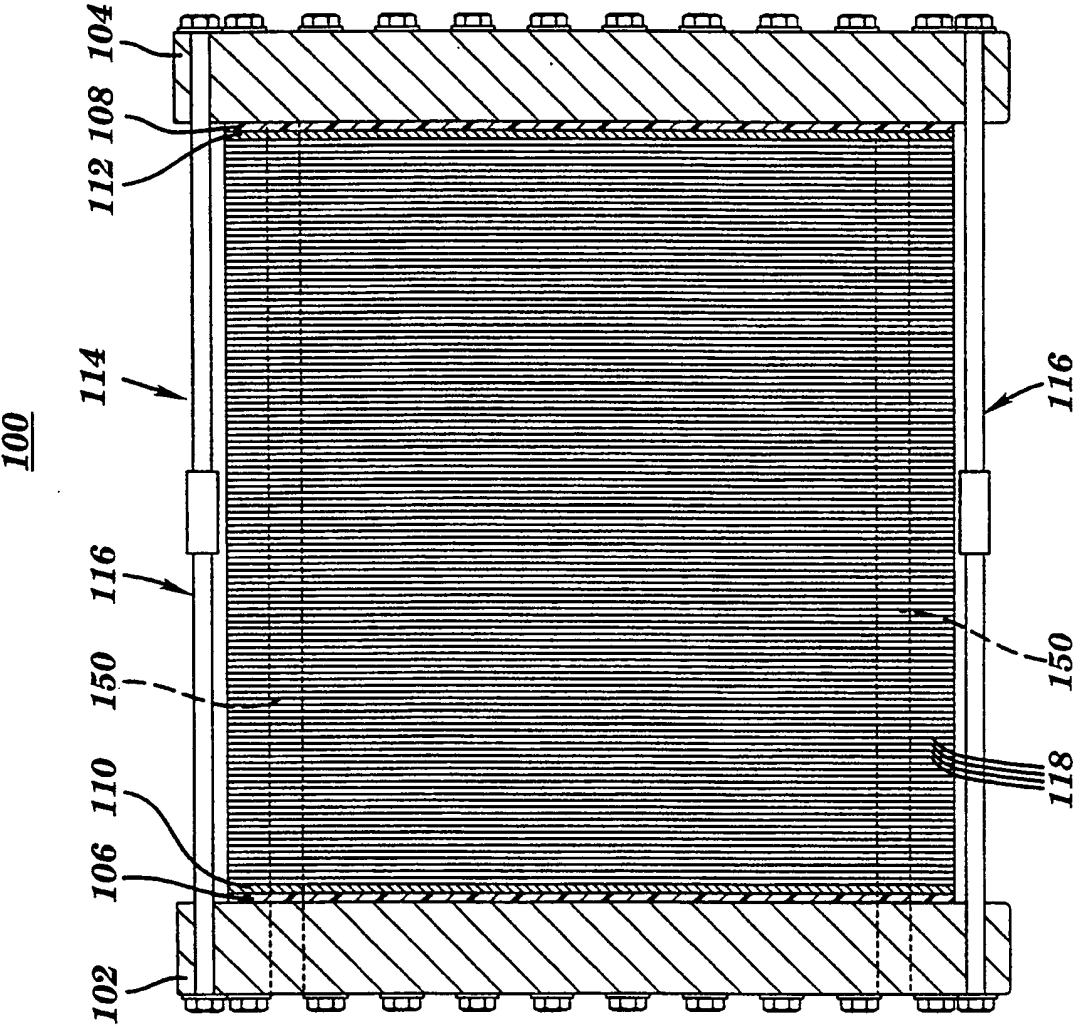
5 selecting a first plate (200) having a first face (202) and a second face (504) directed opposite to said first face, said first face comprising a flow field face including a flow field channel (204) thereon, said second face comprising an exterior face, said first plate including an opening (858) extending between said flow field channel and said second face;

10 selecting a second plate (510) having a third face (1202), said third face including a surface portion (1508) thereon, and positioning said third face adjacent said second face; and characterized by:

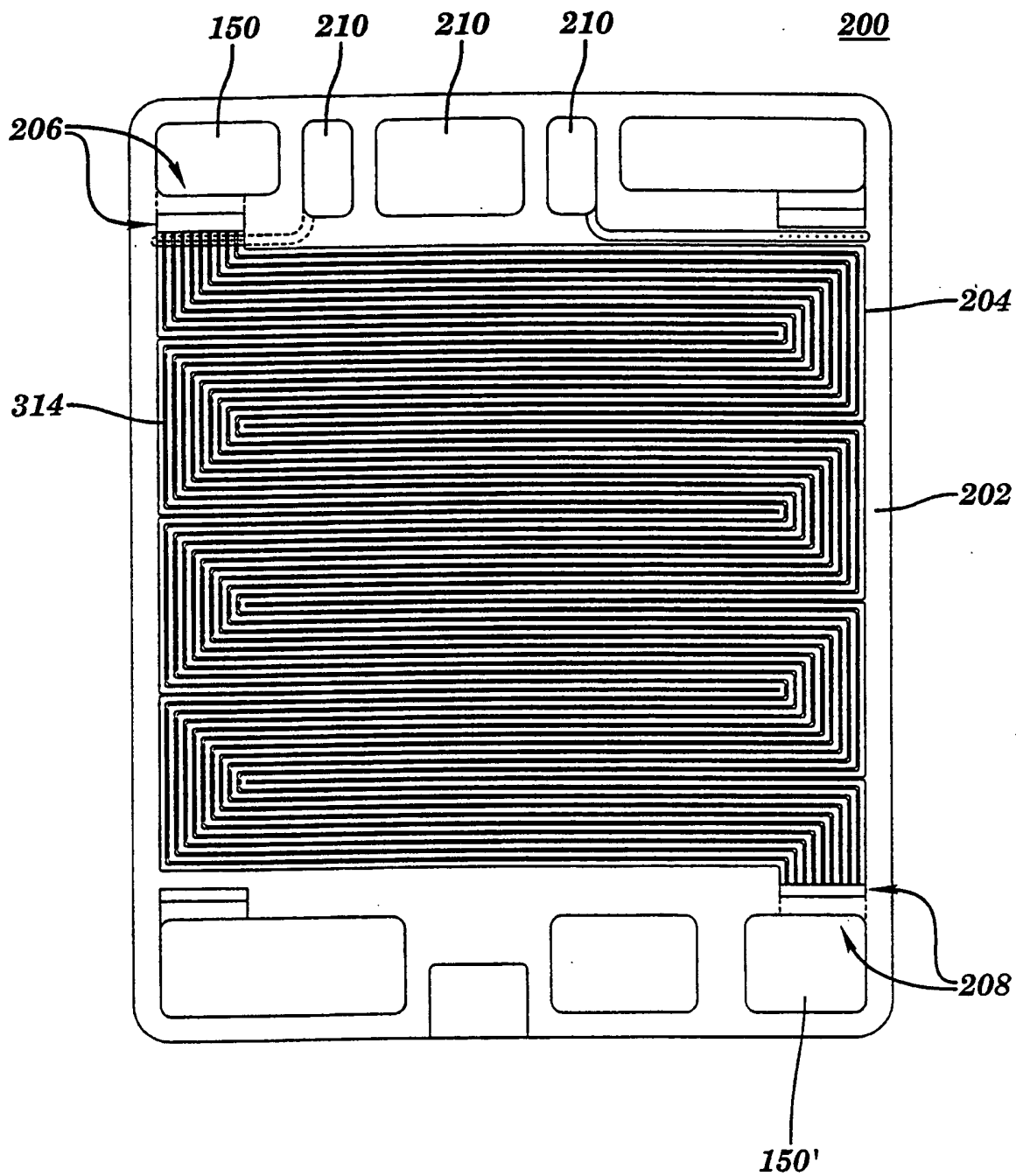
 conducting a fluid portion along a flow path (501) between a manifold (854) and said flow field channel (204), said flow path including said surface portion (508) and said opening (858).

* * * * *

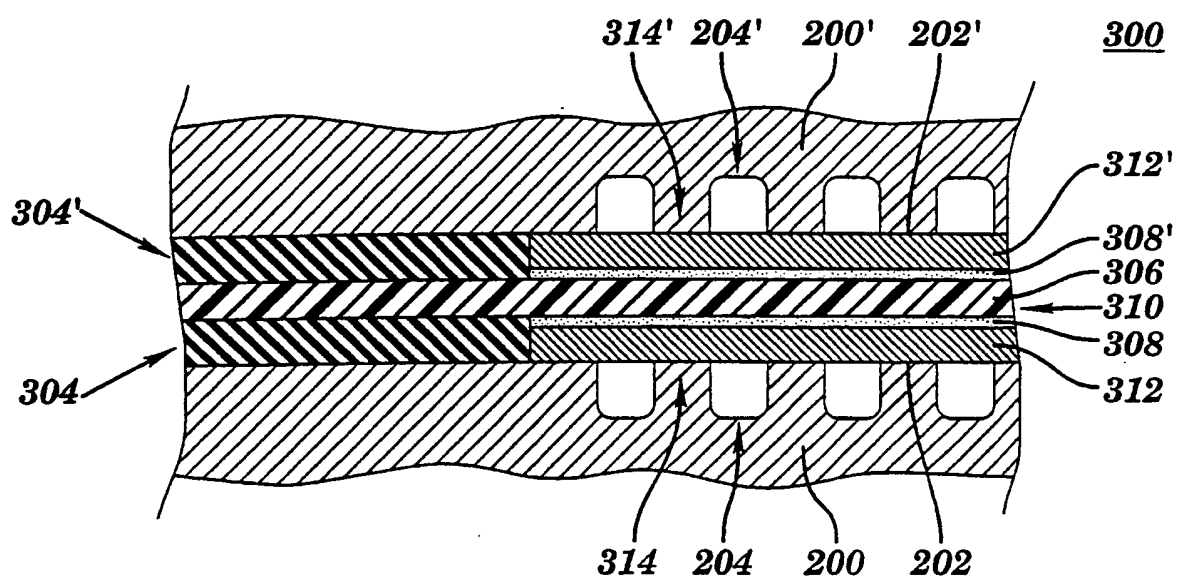
FIG. 1



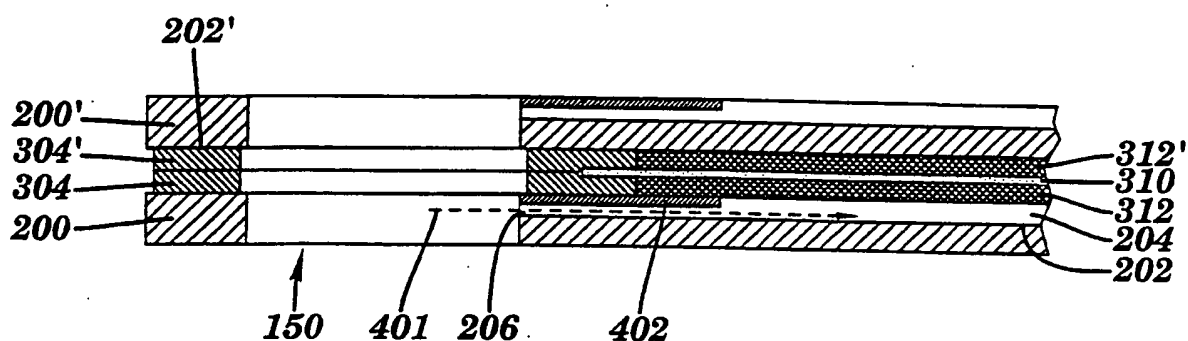
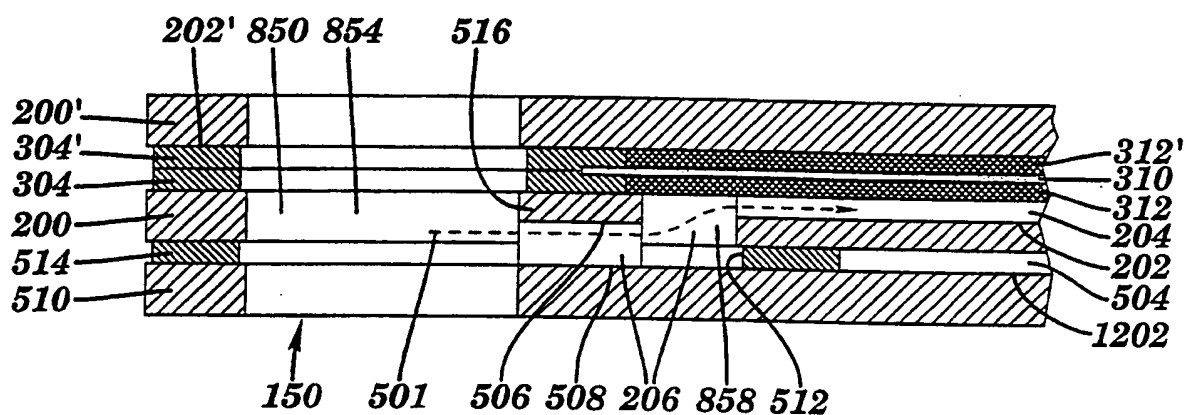
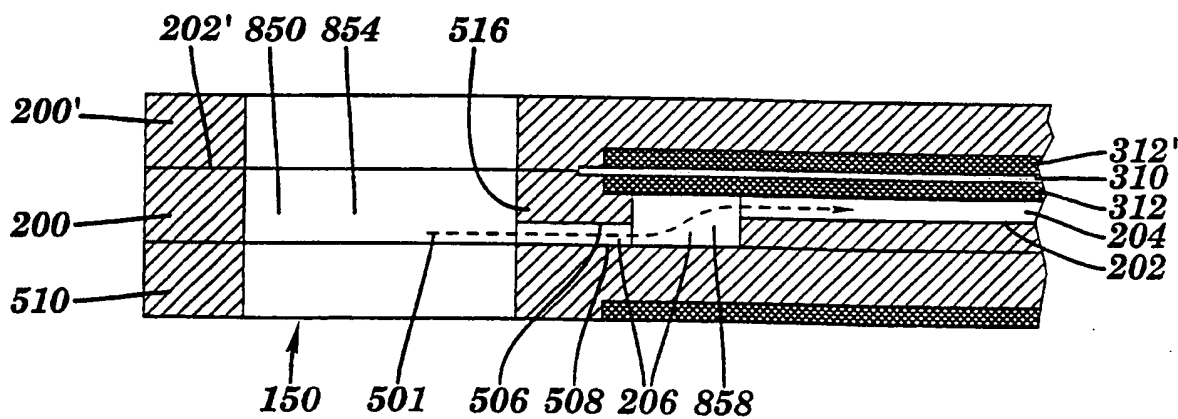
2/10

**FIG. 2**

3/10

**FIG. 3**

4/10

**FIG. 4****FIG. 5****FIG. 6**

5/10

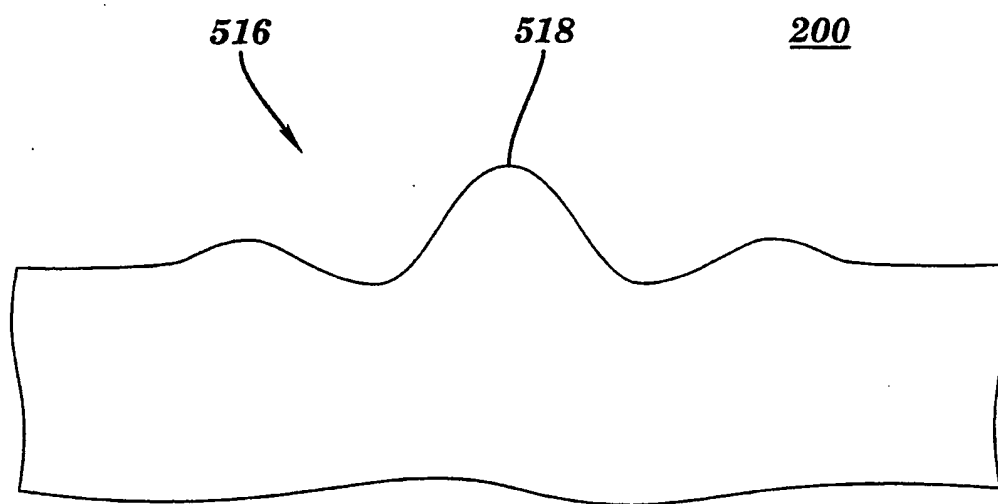
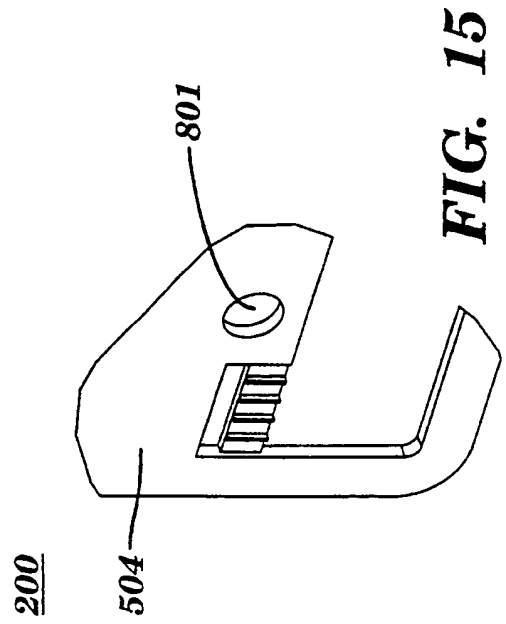
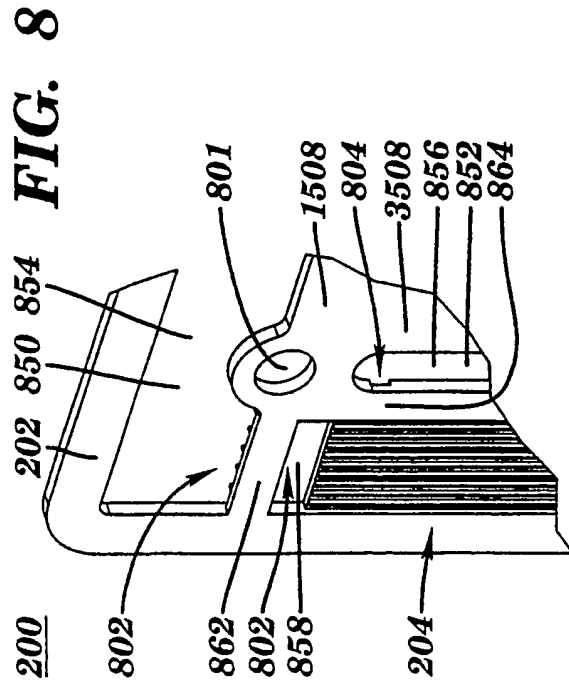
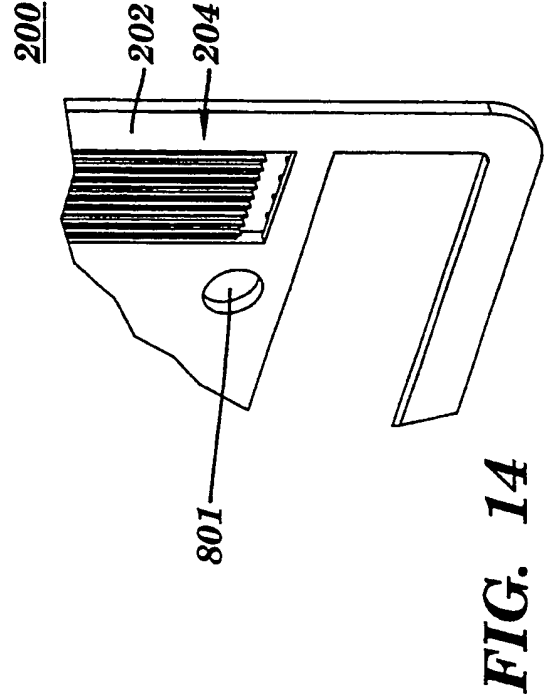
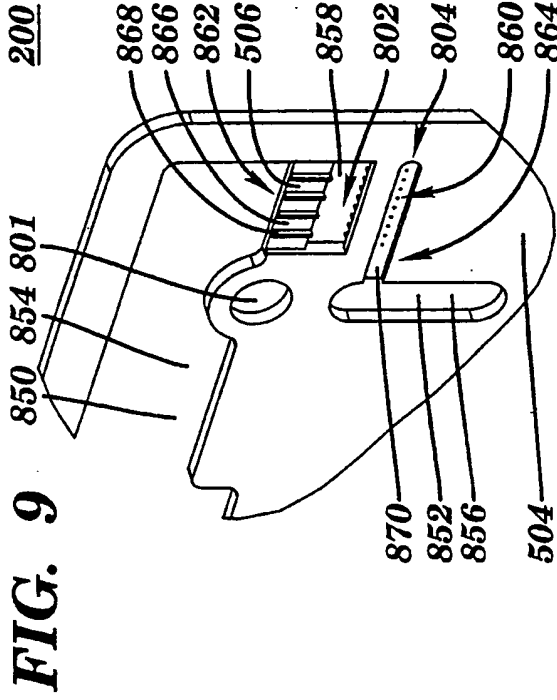


FIG. 7



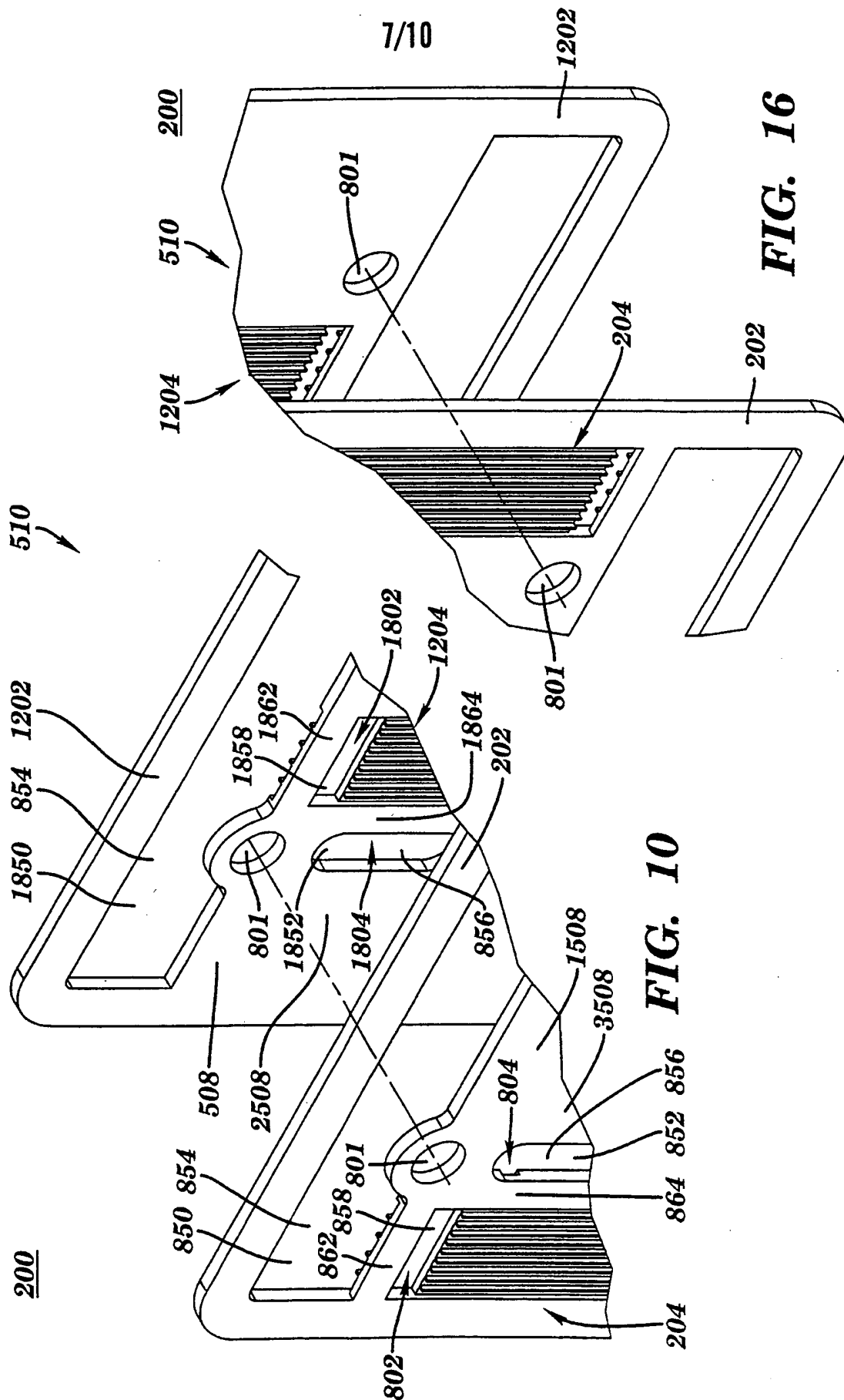


FIG. 16

FIG. 10

8/10

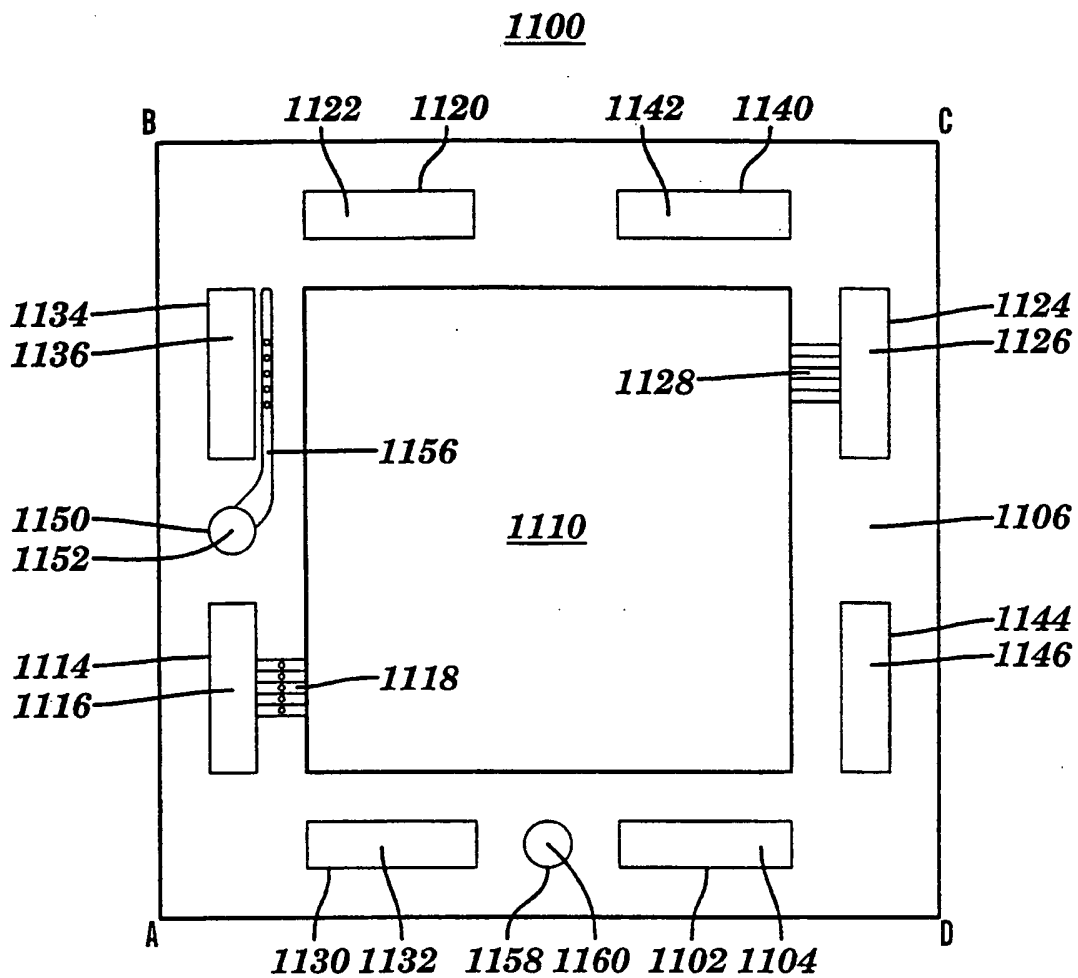
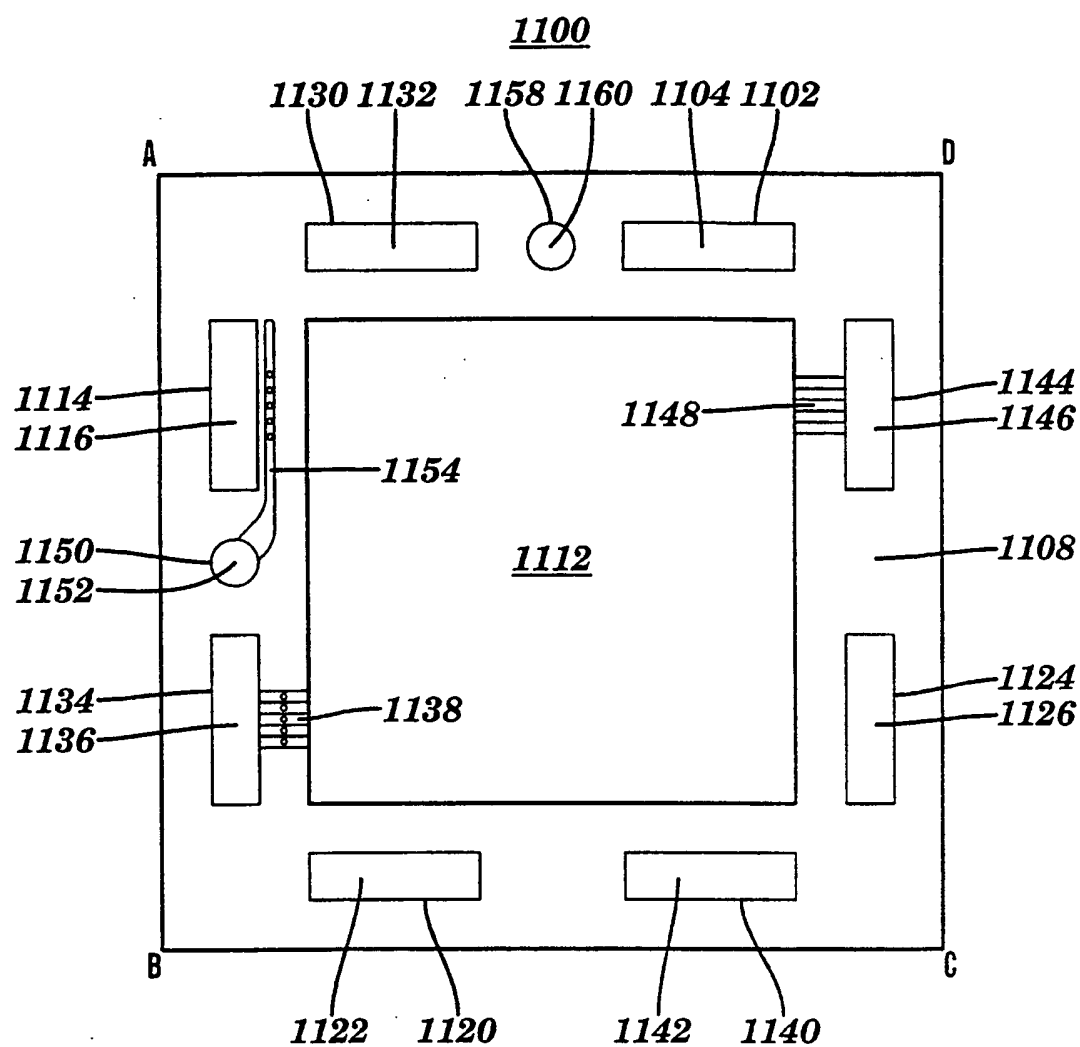


FIG. 11

9/10

**FIG. 12**

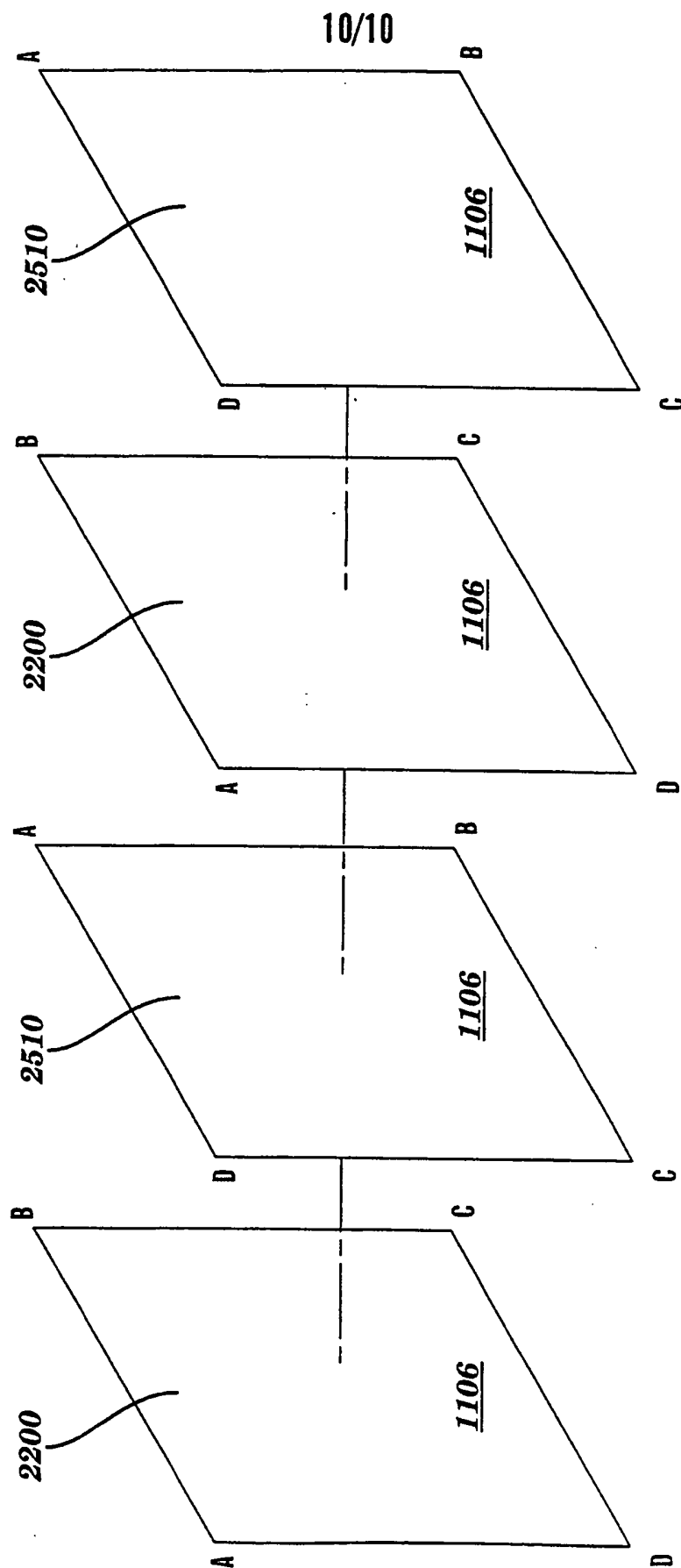


FIG. 13

INTERNATIONAL SEARCH REPORT

Inter. national Application No

PCT/US 99/23283

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01M8/24 H01M8/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 00620 A (UNITED TECHNOLOGIES CORP) 6 January 1994 (1994-01-06) claims 1-8	1-30
A	US 5 750 281 A (WASHINGTON KIRK B ET AL) 12 May 1998 (1998-05-12) claims 1-46	1-30
A	US 4 124 478 A (TSIEN HSUE C ET AL) 7 November 1978 (1978-11-07) claims 1-20	1-30
A	WO 93 13566 A (INT FUEL CELLS INC) 8 July 1993 (1993-07-08) claims 1-6	1-30

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

24 February 2000

Date of mailing of the international search report

02/03/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Battistig, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter: International Application No

PCT/US 99/23283

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9400620 A	06-01-1994	US 5316644 A DE 69311792 D DE 69311792 T EP 0608390 A ES 2105280 T JP 7502306 T	31-05-1994 31-07-1997 13-11-1997 03-08-1994 16-10-1997 09-03-1995
US 5750281 A	12-05-1998	US 5514487 A AU 691387 B AU 4294796 A CA 2208644 A WO 9620510 A DE 69511585 D DE 69511585 T EP 0807323 A JP 10509841 T	07-05-1996 14-05-1998 19-07-1996 04-07-1996 04-07-1996 23-09-1999 13-01-2000 19-11-1997 22-09-1998
US 4124478 A	07-11-1978	NONE	
WO 9313566 A	08-07-1993	US 5523175 A	04-06-1996

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☒ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.